

KNMI NO₂-sonde: Overview of recent campaign activities and future innovations

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1. Introduction

The KNMI NO₂-sonde remains to be the only low-cost, highly accurate, mobile method for making in situ, high-resolution vertical profiles of NO₂ in the boundary layer and troposphere. The NO₂-sonde has been deployed in many international field campaigns in China, the US, and Europe where it has been deployed on weather balloon for full tropospheric profiles, on tethered balloons, and UAVs/drones for planetary boundary layer (PBL) profiling as well as in mobile labs and bicycles for horizontal mapping.

Knowledge of the NO₂ vertical profile near the surface and in the troposphere is critical for retrieval of NO₂, air quality forecasting, and for public health exposure studies. The NO₂-sonde was originally developed in an aim to validate the assumed vertical profile shape needed for air mass factor (AMF) calculation inherent to OMI and other NO₂ retrievals (Section 4).

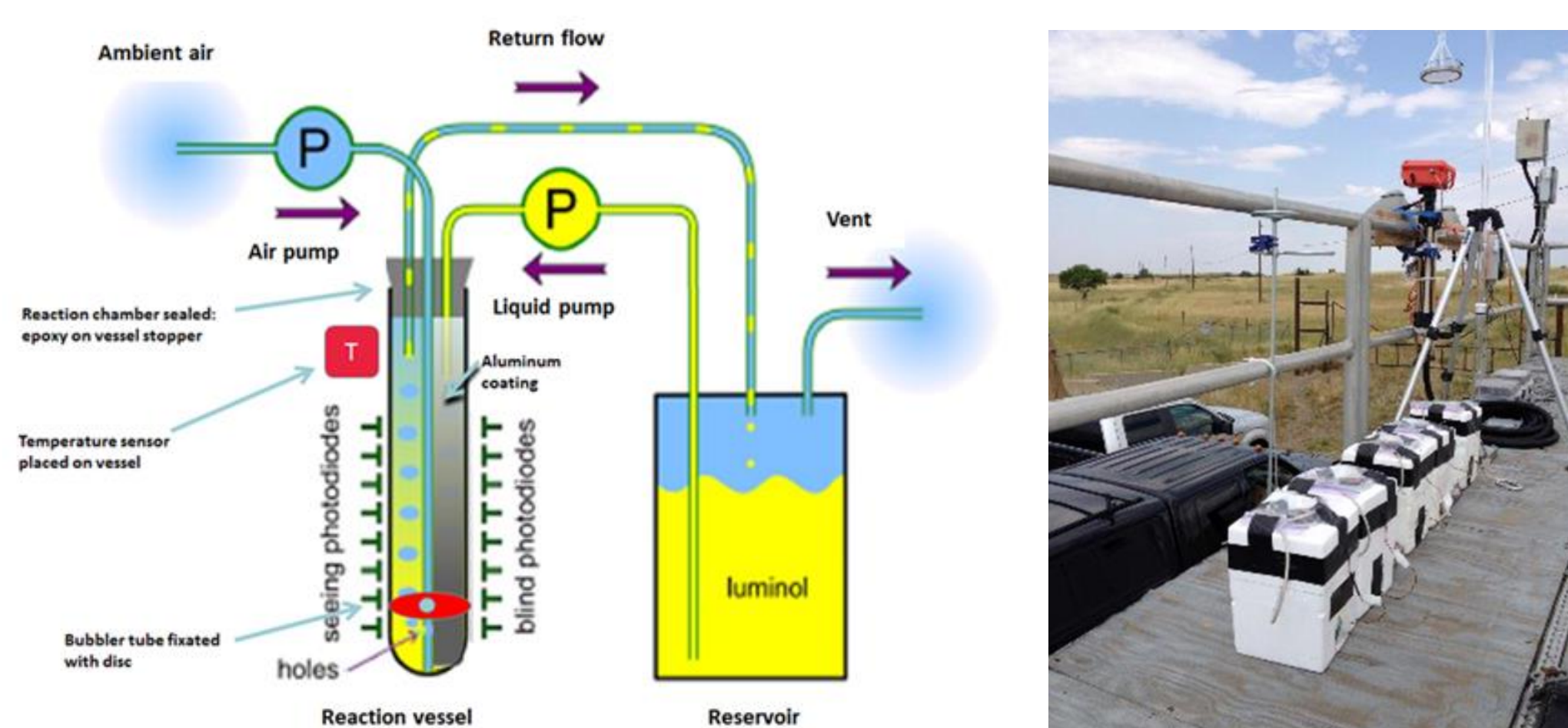


Figure 1. Schematic of the NO₂-sonde (left); NO₂-sondes calibrated with EPA CAPS (right)

2. Innovation & design development

Starting in February 2019, electro-technical students have been working with us to revamp the instrument design including the electronics to make it less labor intensive. The upgrade has included creation of several printed circuit boards (PCB), higher resolution ADC, and an update of the radiosonde interface based on our work with the Swedish company SPARV Embedded. In the coming 2 years we will continue to pursuing a stepwise process to approach industrialization.

RECENT and ONGOING DEVELOPMENTS:

- 1) Integrated PCB for pump electronics
- 2) Digitalization of current design
- 3) Prototype testing with new light sensing technique to lower detection limit & expand measurement range
- 4) Successful test flight with cut-down device for faster retrieval of sonde
- 5) 3-D printed degradable PLA housing and components

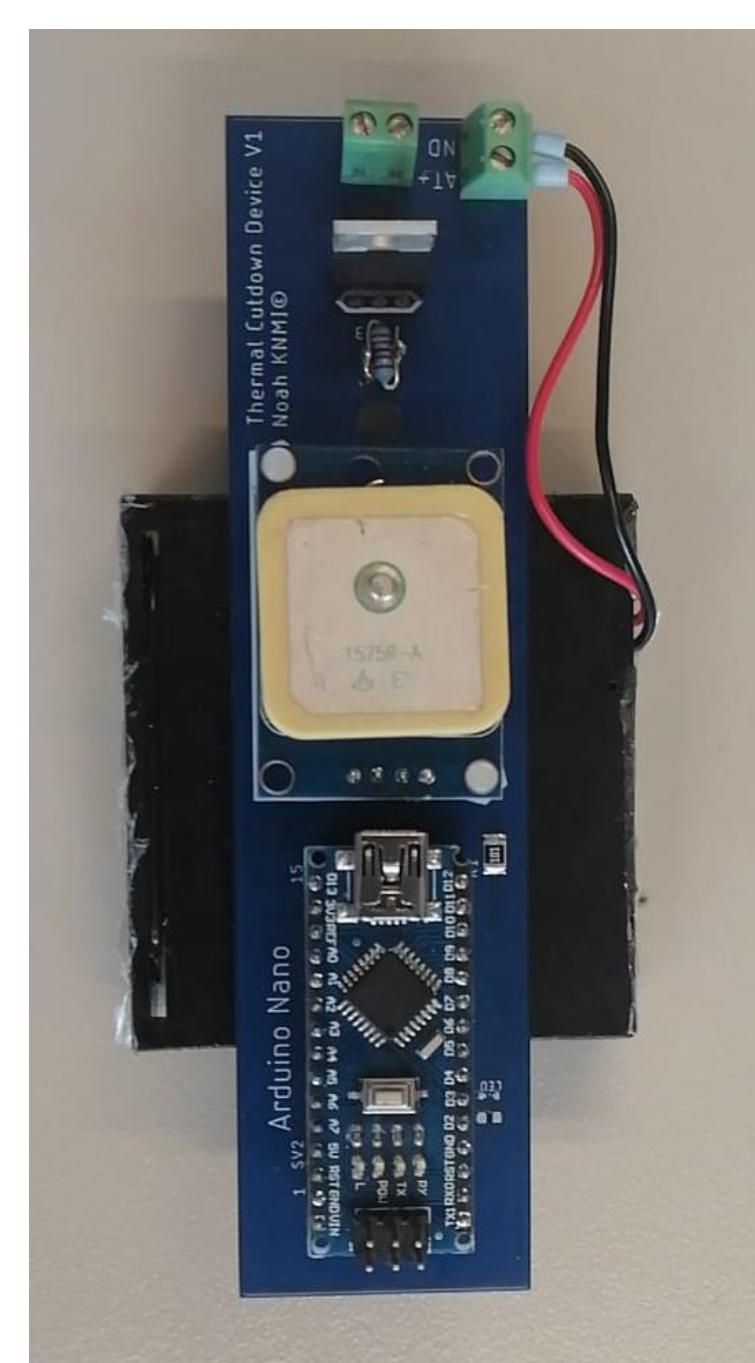


Figure 2. Sonde cut-down device (left); Successful launch of setup 23 Aug 2019 (right).

3. Recent measurements

In summer 2018, drone measurements were carried out in China using the NO₂-sonde and ozonesondes as shown in Figure 3. The drone was used to profile up to 1-1.5 km and was operated for both day and night flights. The profile shown in Figure 3 was made on 4 June 2018 at 08:00 LT. Observations include nocturnal features, like folding down of layers to the surface with PBL collapse and inverse NO₂-O₃ relationships.

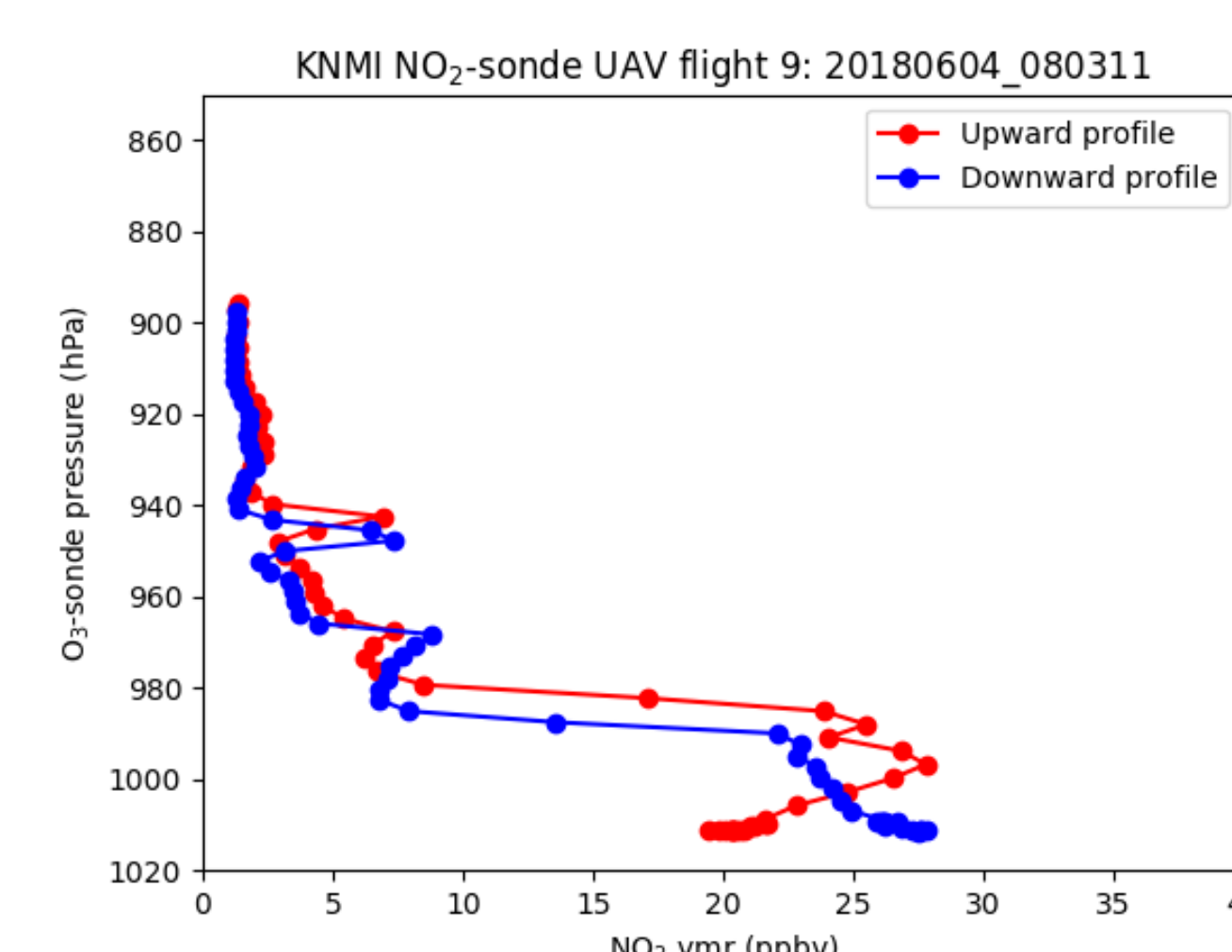


Figure 3. NO₂-sonde profiles [ppbv] measured on board drone (left); NO₂-sonde drone setup (right).

May 2019, mobile measurements were made with the NO₂-sonde in coastal Louisiana as a part of the **NASA, SCOAPE-BOEM campaign** in support of offshore ship measurements.

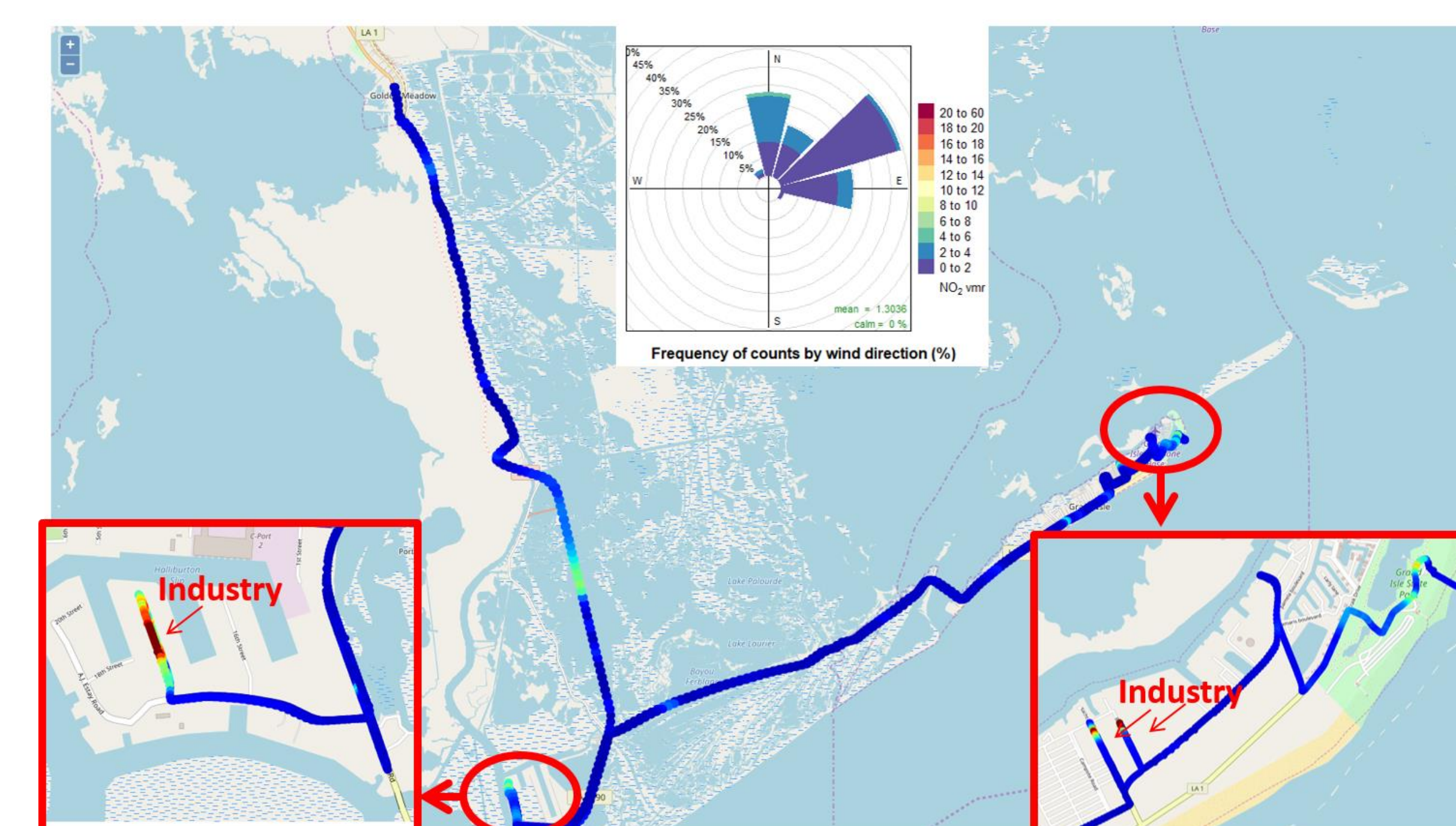


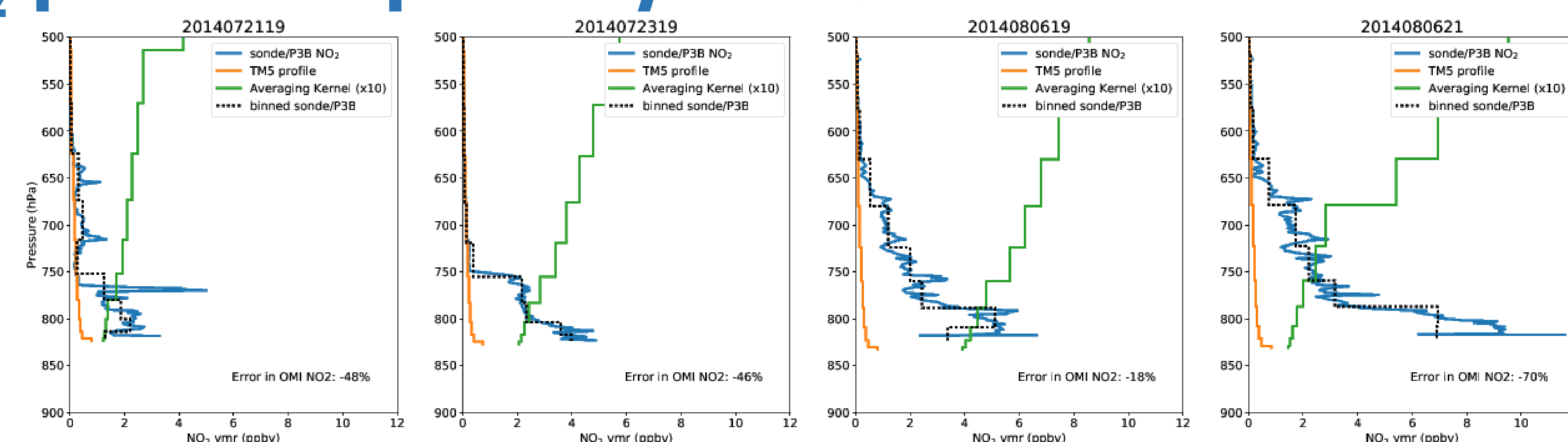
Figure 4. NO₂ mapped by the sonde in coastal Louisiana, 14 May 2019. Inset shows prevailing wind direction.

4. OMI NO₂ profile shape analysis: QA4ECV and TM5

DISCOVER-AQ, Denver:

NO₂-sonde + Aircraft
Binned sonde + aircraft
Model: TM5 (1x1 deg)
OMI QA4ECV AvK

OMI colocation targeted at pixels with similar surface height



What's next ?

Future Campaigns & TROLIX '19: the NO₂-sonde will fly during the next TROPOMI validation campaign at Cabauw, NL starting 9 September 2019. We hope to be involved in follow-up NASA – BOEM campaigns as well as validation opportunities for GEMS and TEMPO.

WANTED in 2020: The NO₂-sonde team is currently searching for an electronics students to continue the next set of innovations internship positions for 3-6 months starting in 2020 are still available. We are also actively searching for industrial partners capable of making custom chemical solutions.

WEBSITES:

<http://www.tropomi.eu/data-products/trolix19-campaign>

<https://www.knmi.nl/research/satellite-observations/projects/city-sonde-science-css>